



Pathogenesis and Economic Impacts of Bovine Digital Dermatitis in Dairy and Beef Cattle

Samantha Cristine Balduino, Ester Raiane Fernandes Medeiros, Gabryelle Moreira de Oliveira, Kelly Cristhina Moessa, Siguinei Souza da Silva, Bruno Rodrigo de Medeiros, Isabela Gonçalves da Silva and Sérgio Eustáquio Lemos da Silva*

University Center of Triângulo, UNITRI, Brazil

*Corresponding Author: Sérgio Eustáquio Lemos da Silva, University Center of Triângulo, UNITRI, Brazil.

DOI: 10.31080/ASVS.2025.08.1029

Received: May 05, 2026

Published: June 05, 2026

© All rights are reserved by Sérgio Eustáquio Lemos da Silva., et al.

Abstract

Bovine digital dermatitis (BDD) is a highly contagious infectious disease affecting the hooves of cattle and represents a major cause of lameness in both dairy and beef production systems worldwide. This study aims to analyze the complex microbiota involved in BDD, identify virulence factors, and describe the environmental and management-related risk factors that favor its dissemination. Furthermore, it evaluates the significant economic impacts and productivity losses associated with the disease. BDD is characterized by painful ulcerative lesions in the interdigital region, primarily associated with a synergistic consortium of anaerobic bacteria. Species of the genus *Treponema* are recognized as the primary etiological agents, though other pathogens such as *Fusobacterium necrophorum*, *Dichelobacter nodosus*, and *Porphyromonas levii* play critical roles in lesion development and persistence. Environmental stressors, including excessive moisture, poor hygiene, high stocking density, and inadequate biosecurity protocols, are major predisposing factors. The economic consequences are substantial, characterized by a marked reduction in milk yield, impaired reproductive performance, premature culling, and rising treatment costs. A comprehensive understanding of the etiological agents and associated risks is essential for implementing effective preventive measures, such as strategic hoof trimming and footbaths, ultimately ensuring animal welfare and herd profitability.

Keywords: *Treponema*; Lameness; Digital Dermatitis; Animal Welfare; Hoof Health; Dairy Cattle

Introduction

Dairy cattle farming is one of the main economic activities of Brazilian agribusiness, with a relevant participation in the national gross domestic product and great social impact, especially in the South, Southeast and Midwest regions. In 2022, Brazil produced about 35 billion liters of milk, being the fourth largest producer in the world, behind only the United States, India, and China [7,13].

The health of the herds is a determining factor for the productivity and sustainability of the dairy activity. In this context, hoof health is extremely important, as it directly interferes with locomotion, welfare, food intake, reproductive efficiency, and milk production of animals [25]. Studies indicate that foot changes are among the main causes of economic losses in intensive production systems, and can reduce milk production by up to 20%, in addition to increasing the risk of early culling of cows [19].

The most common hoof disorders in cattle include laminitis, sole ulcers, white line disease, interdigital dermatitis, and bovine digital dermatitis (DDB). The latter has gained prominence in recent years due to its high incidence in confined dairy herds and the difficulty in controlling it. Characterized by necrotic, moist and foul-smelling lesions in the interdigital region, especially of the hind limbs, DDB is an infectious disease of multifactorial etiology [2,3].

DDB is considered one of the main causes of lameness in dairy cattle and can significantly compromise the welfare and productivity of the animals. The disease is strongly associated with unfavorable environmental conditions, such as excessive humidity, accumulation of organic matter in facilities, and inadequate sanitary management [26]. The main etiological agents involved include anaerobic bacteria, especially of the genus *Treponema*, as well as *Fusobacterium necrophorum*, *Dichelobacter nodosus*, and *Porphyromonas levii* [4,5].

This foot condition has become one of the main causes of lameness in dairy cattle in intensive systems, with a direct impact on productivity, animal welfare and operating costs of the properties. Despite the growing relevance of this disease in the modern livestock scenario, its etiology still presents aspects that require continuous and in-depth investigation [5].

DDB has a multifactorial character, with the participation of different microorganisms, especially bacteria of the genus *Treponema*, as well as *Fusobacterium necrophorum*, *Dichelobacter nodosus* and *Porphyromonas levii*. The interaction between these agents, associated with environmental and management factors, hinders effective control of the disease and makes diagnosis and treatment challenging. In addition, the mechanisms of virulence, persistence, and transmission of agents are not yet fully elucidated [4].

Factors such as the absence of biosecurity protocols, the introduction of asymptomatic carrier animals, and failures in the preventive hoofing routine also contribute to the spread of the disease. In addition, immunosuppression associated with heat stress or inadequate nutritional conditions may favor the installation and persistence of infection [17]. Thus, it is essential to analyze and discuss the main available information about the etiological agents involved in DDB, their virulence factors, and their interactions with the environment and host. Addressing these issues contributes significantly to the understanding of the disease and offers subsidies

for the improvement of more effective preventive, diagnostic and therapeutic measures.

An in-depth understanding of the agents involved, the virulence factors and the risks associated with DDB is essential to reduce its prevalence and mitigate its impacts on modern cattle farming. It is evident that this work also seeks to guide veterinary professionals, producers and researchers on the best practices for sanitary management, minimizing the impacts of the disease on the productive and reproductive performance of animals, in addition to favoring the well-being of cattle.

In view of the complexity and growing relevance of this disease in modern livestock, this study aims to analyze bovine digital dermatitis under three central pillars: (1) to identify the infectious agents involved and their virulence mechanisms; (2) describe the risk and predisposing factors in milk and beef production systems; and (3) quantify the productive and economic impacts of the disease. With this, it seeks to offer technical subsidies to veterinarians, researchers and producers, optimizing control strategies and promoting animal welfare.

Methodology

This study consists of an exploratory and descriptive literature review. Data collection took place between February and April 2025, through a systematized search in the PubMed, SciELO, Google Scholar, and ScienceDirect databases. The following descriptors were used in Portuguese and English: “bovine digital dermatitis”, “infectious agents”, “treponema”, “risk factors” and “cattle lameness”.

The inclusion criteria were: original and review scientific articles published between 2015 and 2025, written in Portuguese or English, that addressed the etiology, pathogenesis, epidemiology, or economic impacts of DDB. As exclusion criteria, duplicate studies, abstracts of events without full text, and papers that did not present technical grounds consistent with the objectives were discarded. In addition, technical guidelines for animal health from the Ministry of Agriculture and Livestock (MAPA) were consulted.

Results and Discussion

Hooves play an essential role in the support and locomotion of cattle, being fundamental for productive performance and animal welfare. Structurally, each member of the cattle ends in two digits,

each surrounded by a corneal capsule composed of keratin, which protects the sensitive and vascularized tissue. The main anatomical regions of the hooves include the wall, sole, bulb, white line, and ranilla, all of which have specific functions related to impact absorption, traction, and weight bearing [14].

Hoof health is directly linked to the animal's general health and zootechnical efficiency, since foot injuries reduce the ability to move, affect food intake and interfere with reproductive performance, leading to a drop in milk production and weight gain [10]. In intensive production systems, the prevalence of foot disorders tends to be higher due to constant contact with hard surfaces, high humidity, and accumulation of feces, factors that favor the emergence of foot diseases such as laminitis, sole ulcers, and bovine digital dermatitis [22].

In addition, anatomical or physiological changes in the hooves, such as pressure imbalances or structural deformations, can compromise animal welfare and cause lameness. In morphometry studies carried out with Nellore cattle, significant differences in hoof structure were observed between confined animals and those kept on pasture, indicating the direct influence of management on foot anatomy [15].

Therefore, understanding the anatomy of hooves and their functional importance is essential for disease prevention, proper hoofing and implementation of effective sanitary management practices. Regular monitoring of the foot condition of the animals, combined with technical knowledge, contributes significantly to the productivity and longevity of the herds [20,21].

DDB is a multifactorial infectious disease that mainly affects dairy cattle, being one of the main causes of lameness and economic losses in livestock. The etiology involves a complex interaction of microorganisms, with bacteria of the genus *Treponema* standing out as the main agents associated with the lesions characteristic of the disease [16]. Recent studies have identified several species of *Treponema* in DDB lesions, including *T. pedis*, *T. medium*, *T. phagedenis*, *T. refringens*, and *T. denticola*. These spirochetes are often found in the deeper layers of the lesions, suggesting their crucial role in the pathogenesis of the disease [2]. In addition to *Treponema*, other bacteria have been associated with DDB, such as *Fusobacterium necrophorum*, *Dichelobacter nodosus*, *Porphyromonas leyii*, *Mycoplasma* spp., *Bacteroides* spp., and *Campylobacter* spp. The concomitant presence of these microorganisms indicates

a bacterial synergism that contributes to the severity and persistence of the lesions [16].

The virulence factors of these agents include the production of proteolytic and collagenolytic enzymes, which facilitate the invasion and destruction of hoof tissues. *Treponema* spp., for example, express adhesins that promote adherence to host cells, as well as proteins involved in motility, such as flagellins, which aid in the spread of infection [18]. The ability to form biofilms is also an important factor in the virulence of these pathogens, providing protection against the host's immune system and increasing resistance to antimicrobial treatments. This characteristic makes it difficult to control DDB and contributes to its chronicity [2].

Understanding infectious agents and their virulence mechanisms is essential for the development of effective DDB prevention and control strategies. Investments in research aimed at elucidating the pathogenesis of the disease and identifying specific therapeutic targets are essential to mitigate the impacts of this disease on cattle farming.

DDB is a disease largely influenced by environmental factors, management and individual characteristics of animals. These elements act in a combined way, favoring the installation and dissemination of the disease in dairy and, to a lesser extent, beef herds. The understanding of the predisposing factors is essential for the formulation of strategies for the control and prevention of the disease [2,8]. Among the main environmental risk factors, high humidity, accumulation of feces and urine in the facilities, and abrasive or slippery floors stand out, especially in intensive confinement systems, such as free-stall and compost barn [8,24]. These conditions promote lesions in the interdigital skin and facilitate colonization by opportunistic microorganisms.

In addition, high stocking density and inadequate ventilation contribute to the persistence of a microclimate conducive to bacterial proliferation. The introduction of infected animals without adequate quarantine is also considered an important vector for the introduction and spread of DDB on disease-free farms [2]. Individual characteristics such as low body condition score, hoof conformation and lactation stage also influence the susceptibility of the animals. Cows in the immediate postpartum period are more vulnerable due to the hormonal and immunological changes typical of the phase, which temporarily compromise the immune response [6].

Another critical factor is the absence of preventive hoofing programs. Lack of periodic maintenance of the foot anatomy can result in deformed hooves, accumulation of dirt in the interdigital region, and greater predisposition to injury and infection [22]. Therefore, according to Andrade [2], the combined presence of these factors establishes an environment conducive to the emergence of DDB. Effective control of the disease depends on the identification of the specific risks of each production system and the adoption of good practices of animal management, hygiene, biosecurity and monitoring.

DDB is one of the main causes of infectious lameness in cattle, especially in dairy herds, causing significant economic losses for producers. The financial impacts associated with DDB are multifactorial, including reduced milk production, increased treatment costs, early culling of animals, and impaired reproductive efficiency [11]. Studies indicate that cows affected by DDB may show a reduction in milk production of up to 1.5 kg per day, depending on the severity of the lesions and the stage of lactation [12]. In addition, the pain and discomfort caused by the disease lead to behavioral changes, such as lower food intake and reduced physical activity, negatively impacting the productive and reproductive performance of animals [9].

Direct costs related to DDB treatment include spending on medications, additional labor, and dressing materials. In a study conducted by Akin and Akin [1], it was shown that effective treatment of DDB can lead to an increase in milk production, offsetting treatment costs in approximately 27 days after starting therapy. However, the lack of adequate treatment can result in chronic injuries, requiring more complex and costly interventions. In addition to direct costs, DDB is also associated with significant indirect losses. The disease is one of the leading causes of involuntary culling in dairy herds, leading to early replacement of animals and increased replacement costs [23]. It is estimated that the average cost per animal affected by DDB ranges between US\$ 150 and US\$ 300, depending on the severity of the case and the conditions of management of the property [23]. Therefore, DDB represents a significant economic challenge for cattle farming, requiring the implementation of effective prevention, early diagnosis, and appropriate treatment strategies to mitigate its financial impacts and promote animal welfare.

Conclusion

Bovine digital dermatitis (DDB) is a complex health challenge, whose solution lies in the integration between microbiological diagnosis, environmental management, and economic analysis. The study shows that the pathogenicity of the disease is enhanced by the synergistic interaction of infectious agents in environments with poor hygiene, making risk factors the main target for control interventions. It is concluded that the quantification of productive impacts is indispensable to justify the investment in preventive and continuous monitoring protocols. Therefore, DDB mitigation in modern livestock farming depends on proactive strategies that prioritize animal welfare as a pillar of the economic viability of beef and dairy systems.

Bibliography

1. Akin I and Akin T. "Economic impact of digital dermatitis treatment on a dairy farm: an application of the break-even analysis". *Ciência Rural* 48.8 (2018): 1-7.
2. Andrade LS. de. "Bovine digital dermatitis: etiology, reservoirs and transmission routes". Dissertation (Master's Degree in Animal Science) - Federal University of Minas Gerais, Belo Horizonte, (2017).
3. Blowey R W. "Claw lameness in cattle". 2. ed. Cheltenham: Old Pond Publishing 160 (2005).
4. Bragg R., *et al.* "Characterization of *Treponema* spp. associated with bovine digital dermatitis lesions in South Africa". *Veterinary Microbiology* 187 (2016): 285-292.
5. Caddey B and De Buck J. "Meta-analysis of the bovine digital dermatitis microbiota reveals distinct microbial community structures". *Frontiers in Cellular and Infection Microbiology* 11 (2021): 685861.
6. Corlevic A T and Beggs D S. "Host Factors Impacting the Development and Transmission of Bovine Digital Dermatitis". *Ruminants* 2.1 (2022): 90-100.
7. Food and agriculture organization of the united nations - FAO. FAOSTAT - Livestock Primary (2022).
8. Ferreira BM., *et al.* "Evaluation of risk factors related to the occurrence of digital dermatitis in dairy cows". *Journal of Veterinary Medicine* 12.2 (2021): 78-84.

9. Gabriel Filho L R A., *et al.* "Bovine digital dermatitis: clinical and economic aspects". *Pubvet* 17.7 (2023): e1421 1-11.
10. GARGANO R G and POGLIANI FC. "The importance of body score in hoof lesions in dairy cattle". *Brazilian Journal of Veterinary Science* 23.1 (2016): 45-52.
11. Gomes RD., *et al.* "Economic impact of digital dermatitis in dairy herds: a systematic review". *Brazilian Animal Science* 22 (2021): e67654.
12. Guimarães M. "Hoof disease causes productive and economic loss". *Buy Rural* 9 (2020).
13. Brazilian institute of geography and statistics - IBGE. Municipal Livestock Production. Rio de Janeiro: IBGE (2023).
14. Lima Soares L., *et al.* "Anatomy and physiology of cattle hooves: a review". *Brazilian Journal of Animal Hygiene and Health* 13.2 (2019): 304-319.
15. Mendonça A C., *et al.* "Hoof morphometry and bone mineral densitometry of the metacarpal and phalanges of Nellore cattle in feedlot and pasture". *Ciência Animal Brasileira* 4.1 (2015): 53-60.
16. Moreira TF, *et al.* "Bovine digital dermatitis: etiology and transmission routes". *Academic Journal: Animal Science* 16.3 (2018): 1-10.
17. Nicoletto SF, *et al.* "Clinical and histopathological evaluation of digital dermatitis lesions in dairy cows". *Brazilian Veterinary Research* 33.8 (2013): 991-996.
18. Nielsen M W., *et al.* "Identification of *Treponema* spp. and other bacteria in digital dermatitis lesions from dairy cattle by molecular methods". *Veterinary Microbiology* 199 (2016): 282-289.
19. Nuss K and Duchet-Suchet E. "Lameness in dairy cattle: Economic impact and preventive strategies". *Livestock Science* 106 (2007): 1-10.
20. Oliveira V and Carniatto C H O. "Laminitis in cattle: literature review". *Annals of EVINCI-UniBrasil* 9.2 (2023): 460-460.
21. Ramos KS. "Occurrence of laminitis in dairy cattle: a literature review". 45 f. Course Completion Paper (Graduation in Veterinary Medicine) - UniFG University Center, Guanambi (2022).
22. Reis I D and Nogueira JM. "Podal affections in dairy cattle". *Revista Agroveterinária do Sul de Minas* 5.1 (2023): 136-154.
23. SCHIPPERS. "The hidden harms of digital dermatitis and how to prevent them from affecting your production". Schippers Brazil (2024).
24. Silva R A., *et al.* "Predisposing factors for the occurrence of foot diseases in dairy cows in feedlot". *Animal Industry Bulletin* 77.1 (2020): 1-8.
25. Silva R A., *et al.* "Hoof welfare and health in dairy cattle: a challenge for intensive systems". *Brazilian Journal of Sustainable Agriculture* 11.1 (2021): 34-42.
26. Weltzien C., *et al.* "Associations between digital dermatitis and body condition, lameness and milk yield in dairy cows". *Veterinary Record* 177.7 (2015): 179.